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**Wolf et al.**

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(54) **DIRECTION AND DISTANCE FINDER**

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(52) **U.S. Cl.** ..... **342/443**; 342/458
(58) **Field of Search** ..... 342/385, 417, 342/419, 443, 457, 458

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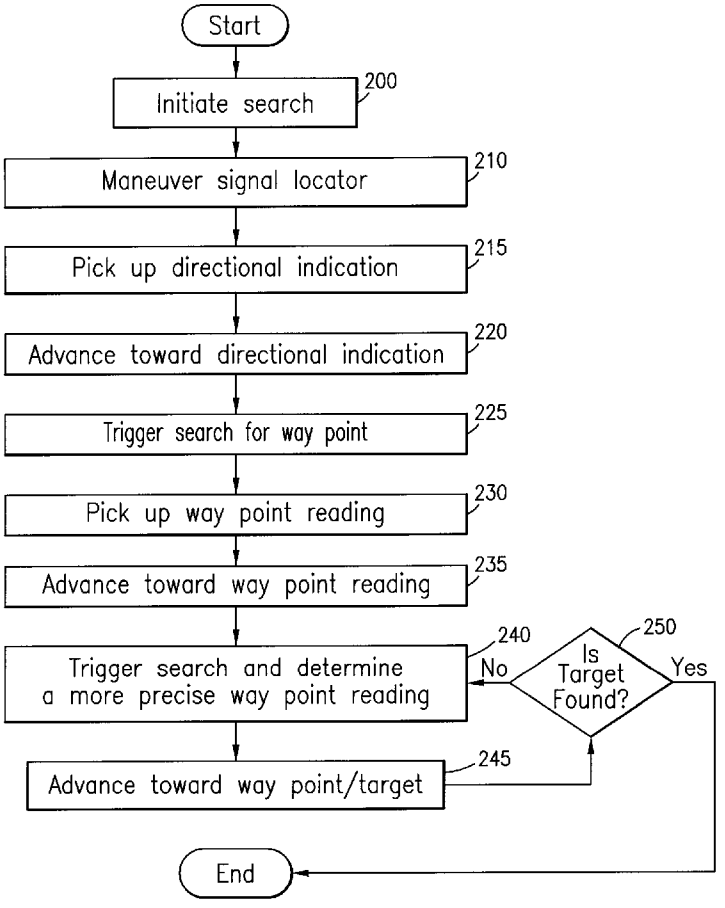
(57) **ABSTRACT**

The present invention relates to a system and method for locating the direction and distance to a RF signal source, primarily for search and rescue. The system and method includes a RF signal locator and a graphical display residing on the signal locator. The receiver graphical display provides the user with an initial way point reading that includes directional and distance data associated with the beacon RF signal source. The directional and distance data is based upon the received RF signals. A processor within the locator receiver receives and measures RF signals emitted by the RF signal source. The locator advantageously provides continuous subsequent way point readings for the user, where the subsequent way point readings include directional and distance data associated with the RF signal source. The distance data provided by the subsequent way point readings is based upon a path loss slope of the received RF signals.

**31 Claims, 9 Drawing Sheets**



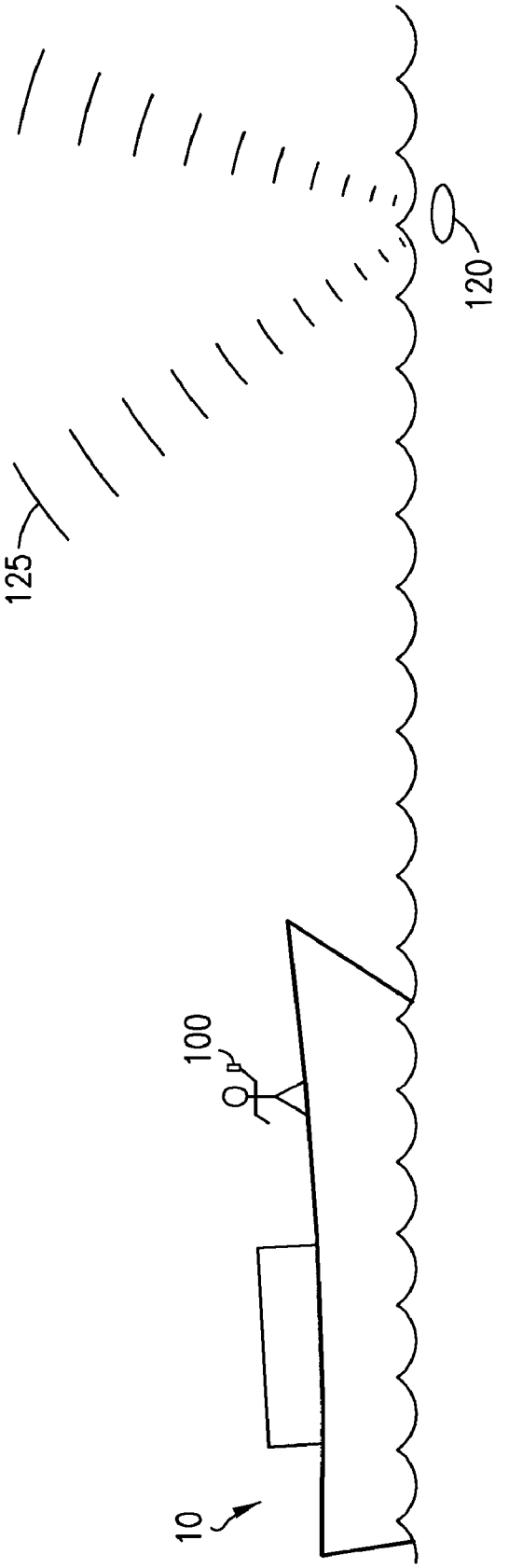



FIG. 1

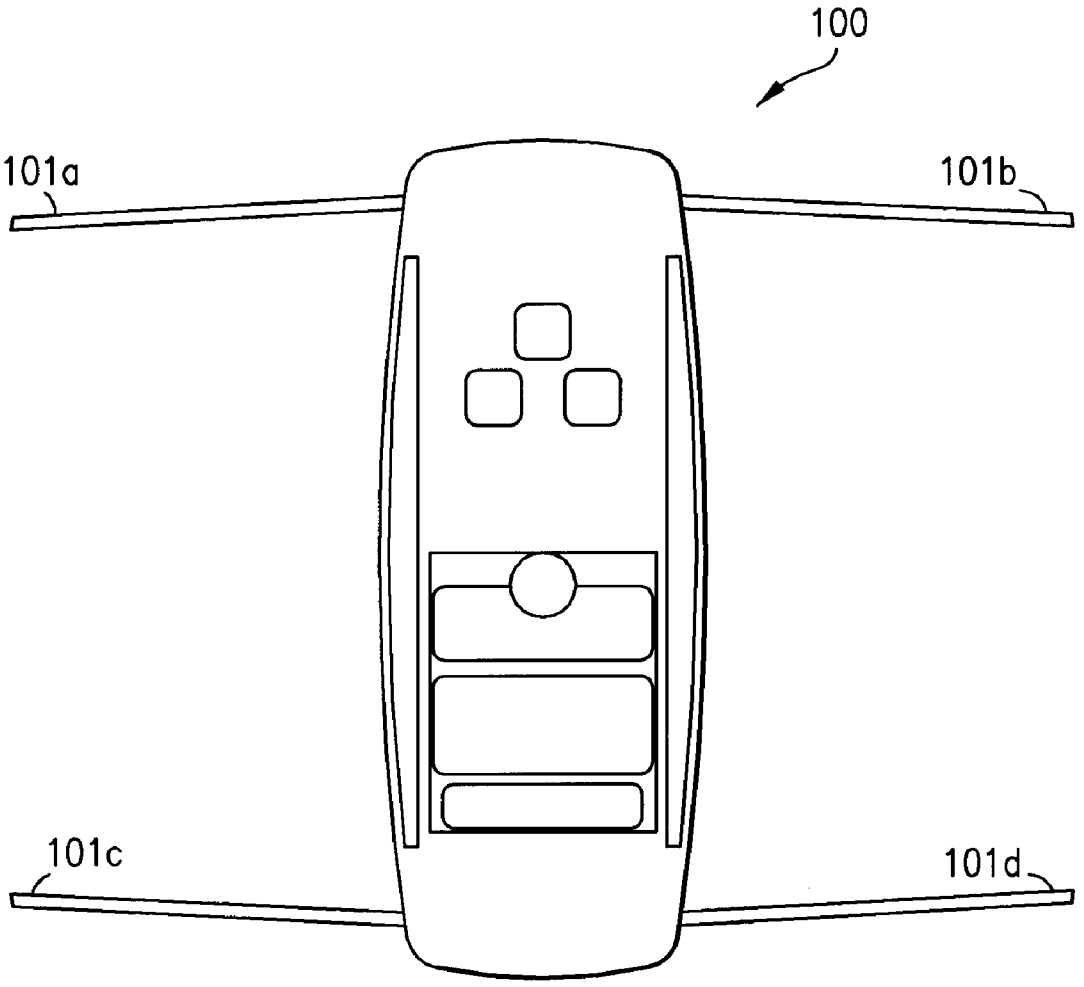



FIG. 2

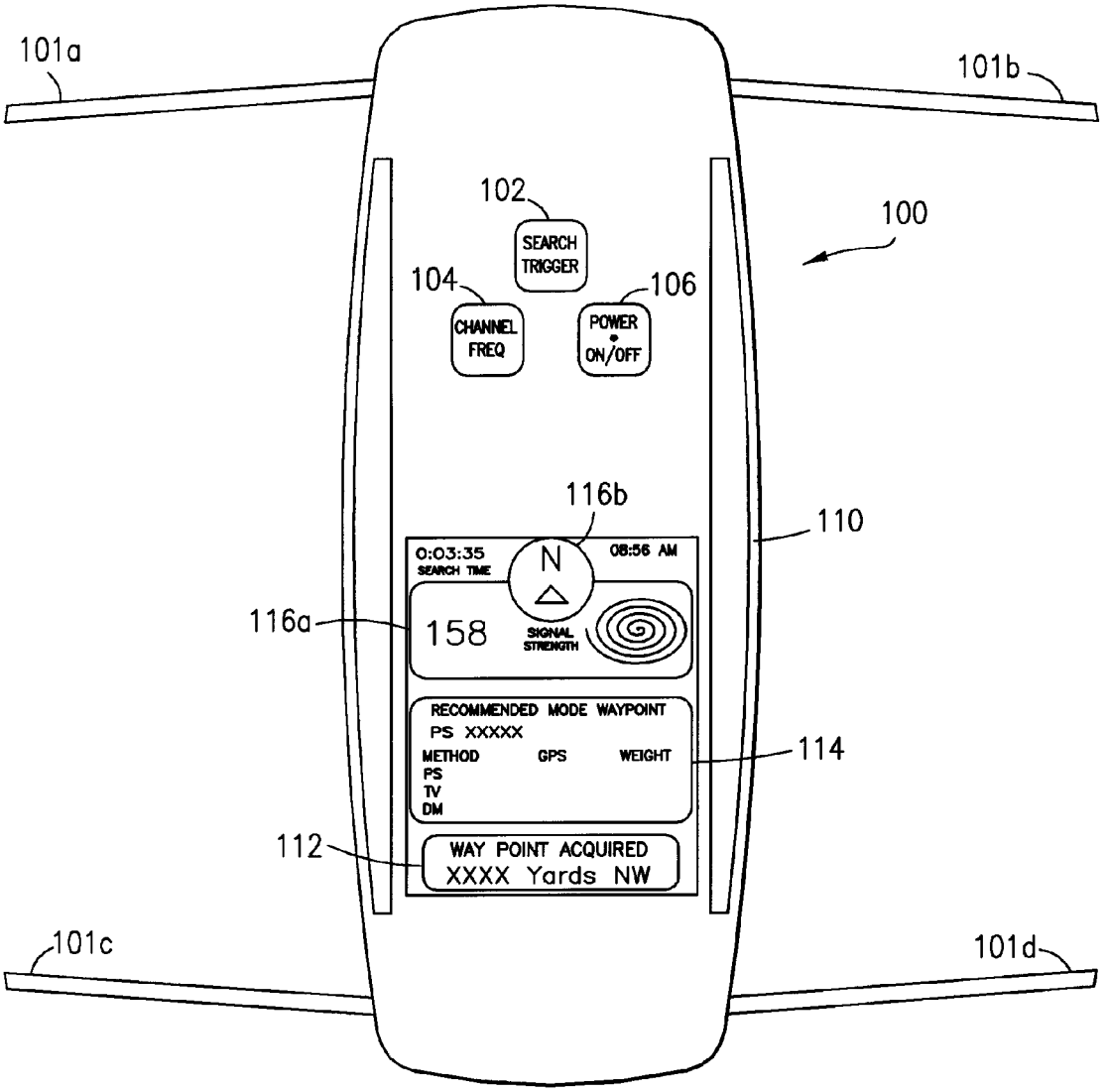

101a
101b
102
SEARCH TRIGGER
100
104
106
CHANNEL FREQ
POWER ON/OFF
116b
110
0:03:35
SEARCH TIME
N
08:56 AM
116a
158
SIGNAL STRENGTH
RECOMMENDED MODE WAYPOINT
PS XXXXX
METHOD
GPS
WEIGHT
114
PS
TV
DM
112
WAY POINT ACQUIRED
XXXX Yards NW
101c
101d

FIG. 3

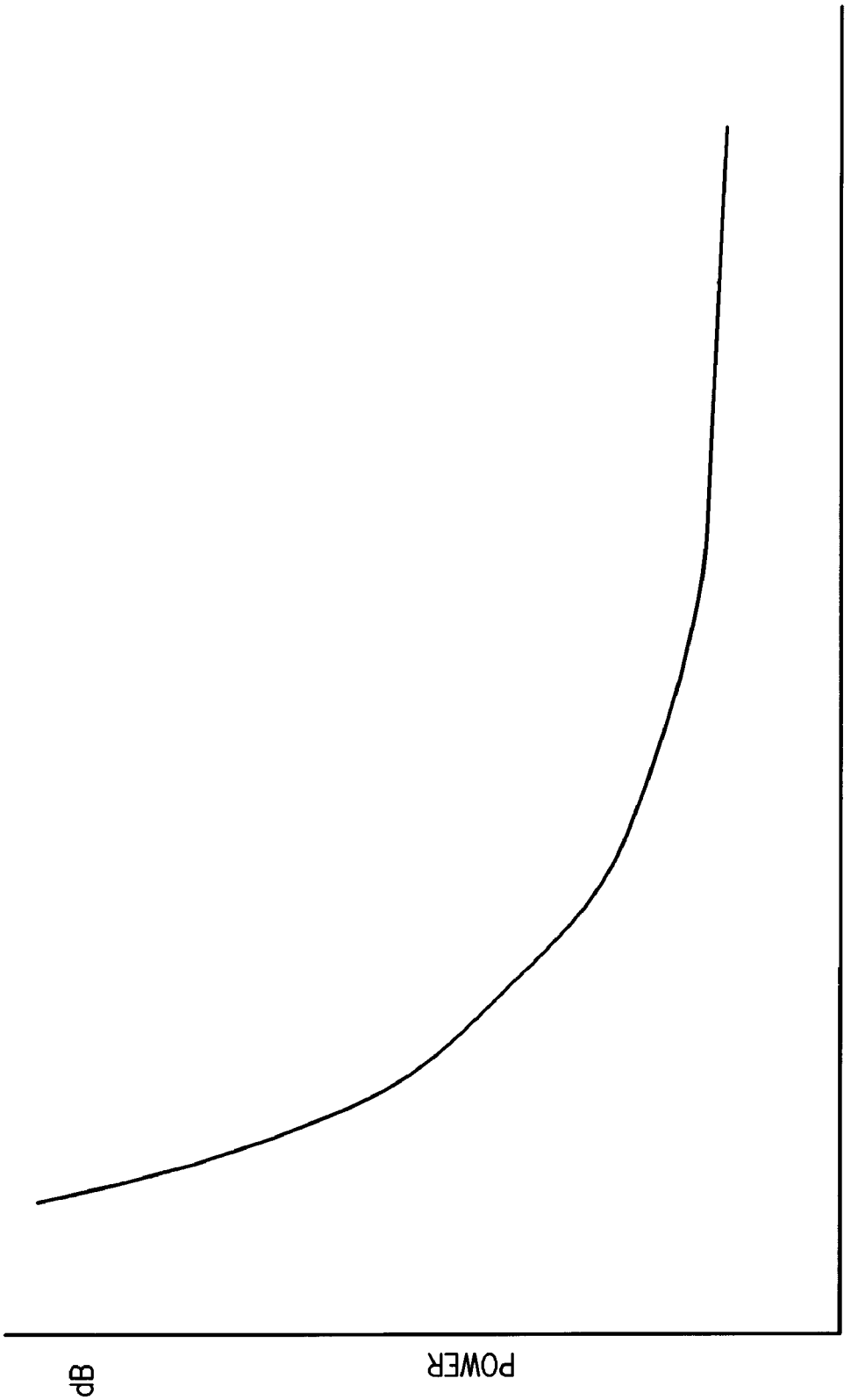



FIG. 4A

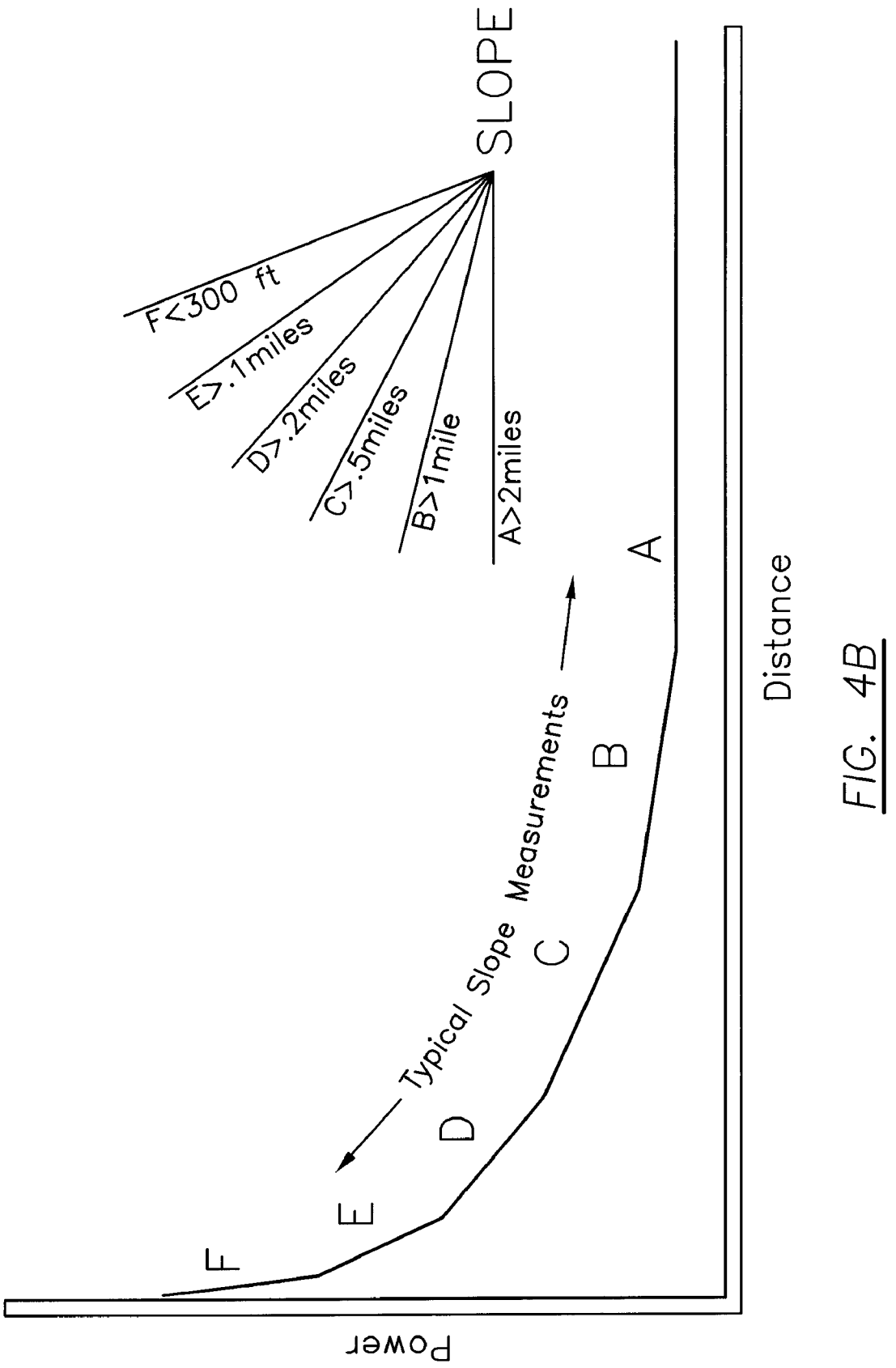

SLOPE
F<300 ft
E>.1miles
D>.2miles
C>.5miles
B>1mile
A>2miles
A
B
C
D
E
F
Typical Slope Measurements
Distance
Power

FIG. 4B

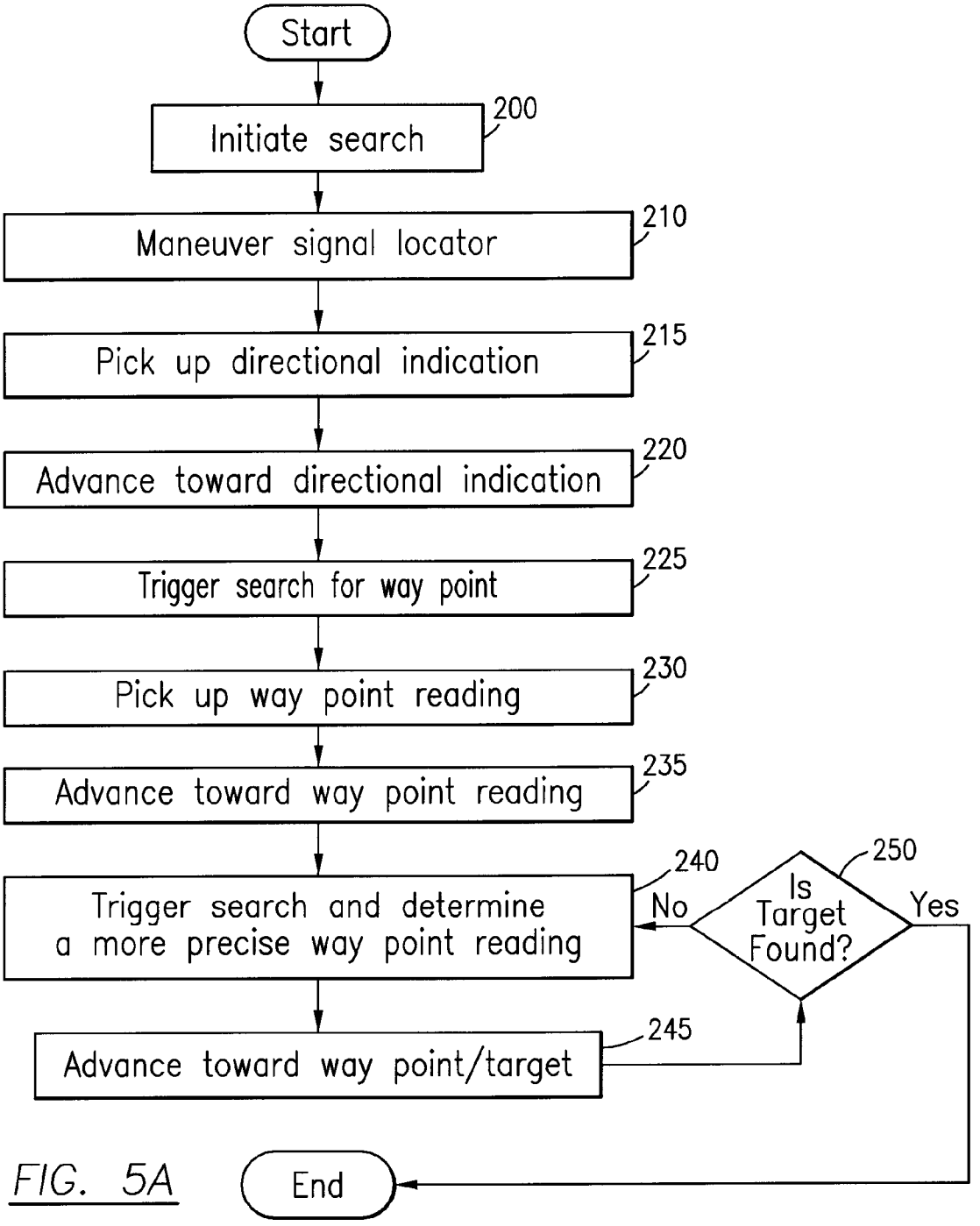

Start
Initiate search
200
Maneuver signal locator
210
Pick up directional indication
215
Advance toward directional indication
220
Trigger search for way point
225
Pick up way point reading
230
Advance toward way point reading
235
Trigger search and determine a more precise way point reading
240
Is Target Found?
250
No
Yes
Advance toward way point/target
245
End

FIG. 5A

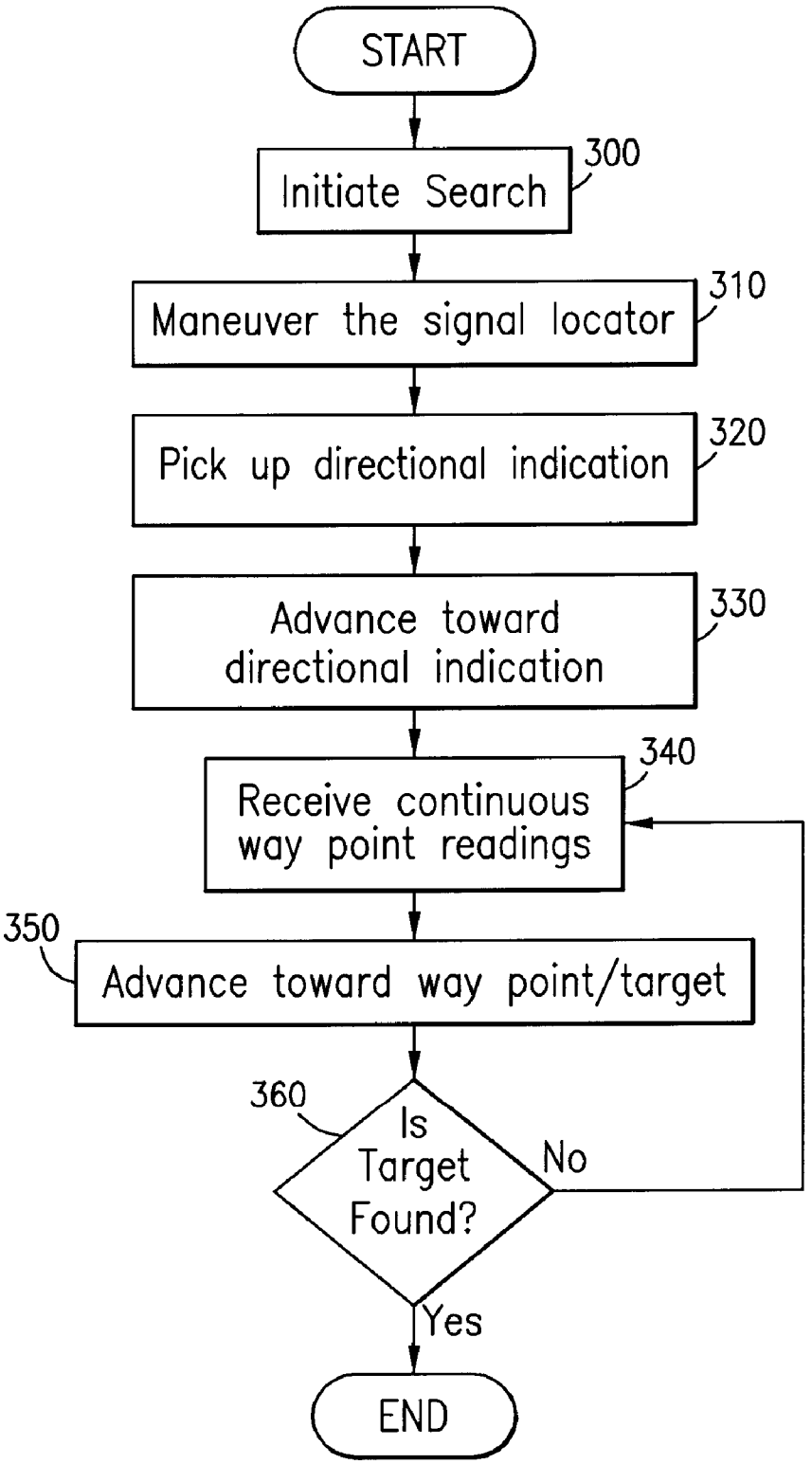

START
Initiate Search
300
Maneuver the signal locator
310
Pick up directional indication
320
Advance toward directional indication
330
Receive continuous way point readings
340
350
Advance toward way point/target
360
Is Target Found?
No
Yes
END

FIG. 5B

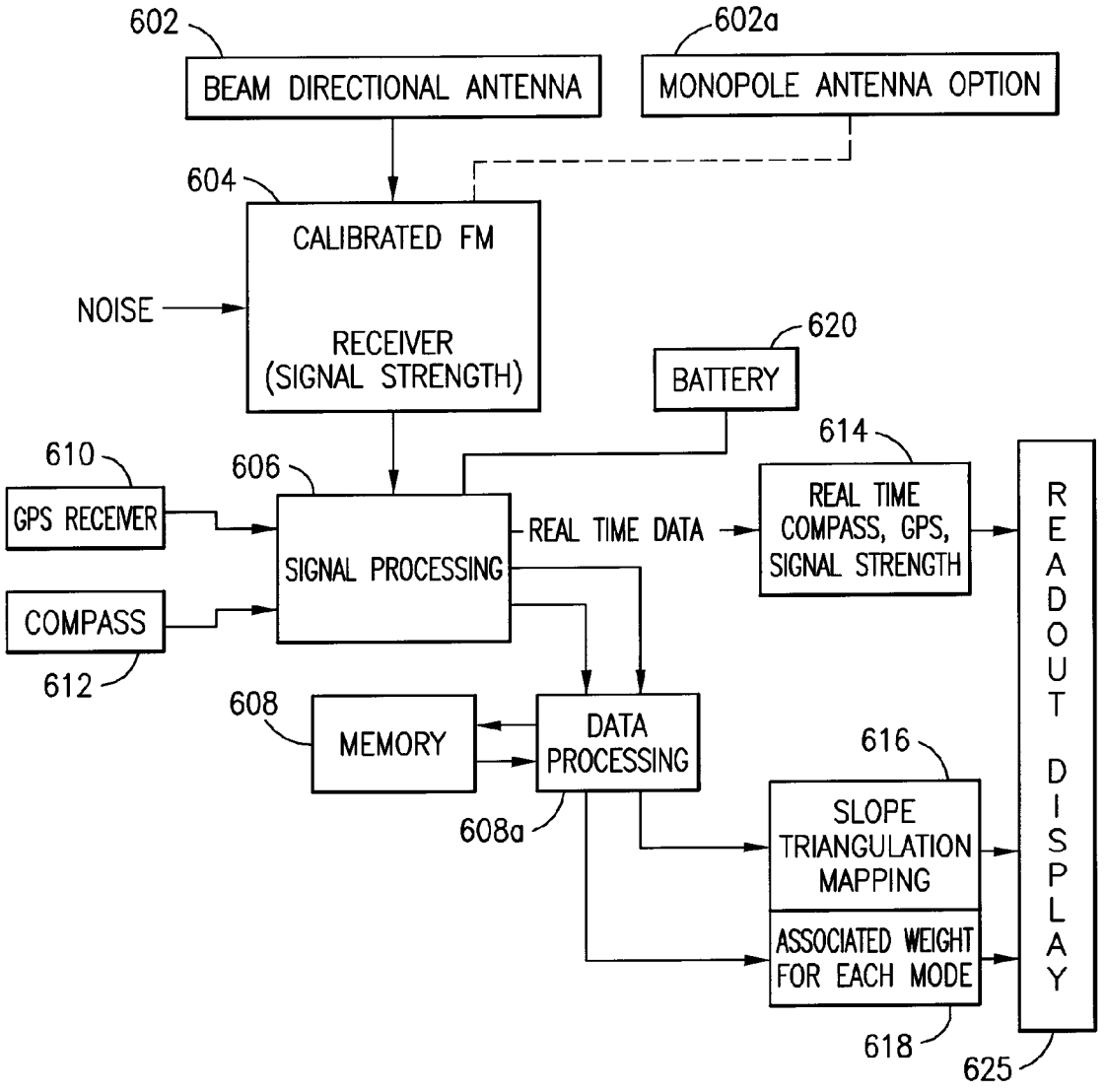

602
BEAM DIRECTIONAL ANTENNA
602a
MONOPOLE ANTENNA OPTION
604
CALIBRATED FM
RECEIVER
(SIGNAL STRENGTH)
NOISE
620
BATTERY
610
GPS RECEIVER
606
SIGNAL PROCESSING
REAL TIME DATA
614
REAL TIME
COMPASS, GPS,
SIGNAL STRENGTH
COMPASS
612
608
MEMORY
DATA
PROCESSING
616
SLOPE
TRIANGULATION
MAPPING
608a
ASSOCIATED WEIGHT
FOR EACH MODE
618
READOUT DISPLAY
625

FIG. 6

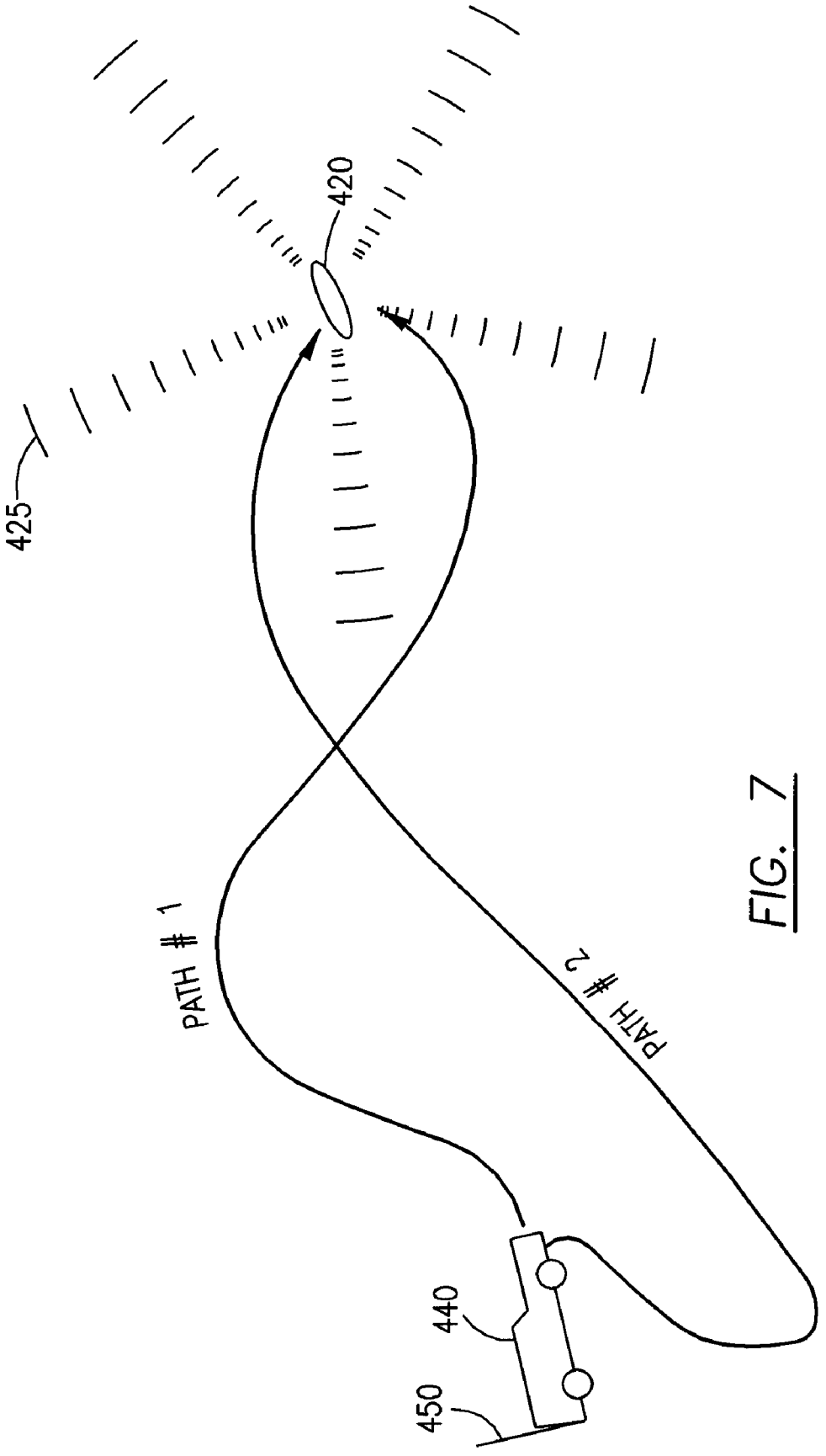



FIG. 7

# DIRECTION AND DISTANCE FINDER

## BACKGROUND OF INVENTION

1. Field of the Invention

The present invention relates to a direction and distance estimation system and method based upon characteristics of the power path loss curve.

2. Description of Related Art

Aircraft emergency locator systems such as ELTs (Emergency Locator Transmitters) and terrestrial location systems such as PLBs (Personal Locator Beacons) are well known in the existing art. Individuals lost at sea and fortunate enough to have emergency location identification devices such as an Emergency Position Indicating Radio Beacon (EPIRB), can send out RF signals with the hopes that their distress signals will be picked up by maritime stations or satellites, which can in turn, relay the information to the proper authorities.

Handheld or mobile location devices and systems can effectively locate the directional parameters associated with distress beacons; however, in order to obtain accurate distance readings, one must employ the use of satellites and global positioning systems (GPS). If a distress beacon emits a GPS signal to orbiting satellites, then a searcher may easily locate the distress beacon based upon the GPS reading. Many distress beacons currently being used are not equipped to transmit GPS readings and merely emit a RF signal for reception by a handheld, mobile, stationary or orbiting satellite receiver. As stated above, the RF receivers used to track and locate a RF signal from a distress beacon effectively locate the direction of the beacon, however reliable distance readings under this application are not possible. The lack of distance readings to the beacon can unnecessarily prolong or possibly imperil a search and rescue operation. If an individual is attempting to locate a person lost at sea, then initial movement of a search vessel is carefully monitored in order to prevent possibly running over the distressed victim. If the search vessel is a great distance from the distressed victim, then valuable time may be lost due to the necessity to move slowly during the searching process. If accurate distance readings were available, then the searching process could be shortened and therefore increase the likelihood of a successful rescue.

Directional and distance information may be equally important to search and rescue operations on land. Searchers may need to locate a distress beacon in dense woods or an urban metropolitan area. The beacon may be used by hikers, off road adventurers, skiers, campers and children. If the searcher is limited to directional data only, then even the effectiveness of a land search could be significantly diminished.

It would therefore be advantageous to provide a method and system for the location of a distress beacon that would provide the searcher with accurate distance and direction estimations. By providing a searcher with distance and directional estimations, the search time may be reduced significantly without endangering the distress victim. Although, the search and rescue operation has been discussed in association with sea and water rescue, distance estimations are also advantageous in regard to terrestrial search and rescue missions. It would also be advantageous if a handheld device facilitated the operation of the present system and method.



## SUMMARY OF INVENTION

The present invention provides a system and method for locating the source of a RF signal. The present invention enables a user to locate the source of a RF signal as emitted by a distress beacon during a search and rescue operation. The present invention advantageously not only provides directional data as to the direction of the RF signal source, it also provides an estimated distance between a receiver and the RF signal source. A receiver according to the present invention advantageously provides direction and distance estimates based upon signal strength in a certain direction or over a certain distance.

In one exemplary embodiment of the present invention, a searcher using a signal locator (RF receiver) obtains the direction of the RF signal source, i.e., the distress beacon. The direction may be ascertained based upon signal strength readings taken by the locator where the strongest signal reading emits from the direction of the beacon. After obtaining the signal direction, the locator stores the initial RF signal strength reading and provides an estimated distance reading. The initial directional data and distance data provide an initial way point reading. The user may then proceed in the indicated direction and the locator produces continuous subsequent way point readings. The subsequent distance readings may be determined based upon the path loss slope of the received RF signals. As the distance between the receiver and beacon decreases, the path loss slope dramatically increases. The path loss slope is the x-y graph of the beacon signal power strength as a function of distance from the receiver to the RF beacon. The present invention advantageously exploits this phenomenon in order to provide accurate and effective distance estimations.

It is therefore an object of the present invention to provide a system that includes a signal locator where a graphical display resides on the signal locator. The graphical display provides the user with an initial way point reading that includes directional and distance data associated with the RF signal source. The directional and distance data is based upon the received RF signals. A processor within the locator receives, measures and stores RF peak signal strength of transmissions emitted by the RF signal source. The locator advantageously provides continuous subsequent way point readings for the user, where the subsequent way point readings include directional and distance data associated with the RF signal source. The distance data within the subsequent way point readings may be based upon a path loss slope of the received RF signals.

It is therefore another object of the present invention to provide a method for locating a RF signal source using a signal locator comprising the steps of: initiating a search mode for the signal locator; obtaining a direction for the RF signal source based upon a RF signal readings; moving a certain distance with respect to the direction of the signal and obtaining an initial waypoint reading, where the initial way point reading is based upon the rate of change of the RF signal strength as received by the signal locator; continuing to traverse with respect to the initial way point reading; and continuously obtaining subsequent way point readings based upon subsequent directional readings and subsequent distance readings, where the subsequent distance readings are based upon the rate of change of the RF signal strength as received by the signal locator.

It is therefore another object of the present invention to provide a method for locating a RF signal source using a signal locator comprising the steps of: initiating a search using the signal locator; maneuvering the signal locator

toward a plurality of compass directions in order to obtain a RF signal strength in the plurality of compass directions; obtaining a direction for the RF signal source based upon a RF signal strength in the plurality of compass directions; providing an initial compass reading toward the signal source; advancing the signal locator in the direction of the initial compass reading; initiating a way point reading, based on the directional readings and distance readings, where the distance readings are based upon the rate of change of the RF signal as received by the signal locator; continuing to advance the signal locator; initiating a subsequent way point reading, based on subsequent directional readings and subsequent distance readings, where the subsequent distance readings are based upon the rate of change of the RF signal as received by the signal locator; continuing to advance the signal locator; and repeatedly initiating subsequent way point readings until the RF signal source is located.

In accordance with these and other objects which will become apparent hereinafter, the instant invention will now be described with particular reference to the accompanying drawings.

## BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** shows a symbolic exemplary overview of a locating system according to the present invention.

FIG. **2** shows a top plan view of a locator (RF) receiver according to the present invention.

FIG. **3** shows a top plan view of the receiver shown in FIG. **2** including an exemplary graphical display according to the present invention.

FIG. **4**A shows a graph of RF signal strength path loss characteristics.

FIG. **4**B shows a graph displaying exemplary slopes associated with a path loss curve according to the present invention.

FIG. **5**A shows a flow chart describing a preferred locating method according to the present invention.

FIG. **5**B shows a flow chart describing an alternate exemplary locating method according to the present invention.

FIG. **6** is a block diagram of the operation of the locator receiver to provide path loss slope data.

FIG. **7** is another exemplary application of the location system according to the present invention.

## DETAILED DESCRIPTION

The present invention provides a system and method that enables swift and accurate location of a RF signal source such as emitted by a distress beacon. The present invention advantageously uses path loss slope readings in order to eventually locate the RF signal source that is transmitted by the distress beacon. The present invention enables a user to acquire data with a handheld device and determine direction and distance of a RF signal source. The direction is determined based upon signal strength and the distance reading may be determined based upon power level changes that occur over the distance traveled, defined as power path loss slope.

Referring now to FIG. **1**, a symbolic exemplary overview of a rescue directional locating system according to the present invention is shown. A RF transmitting beacon **120** floats on a body of water or is attached or held above the water by a person requiring location and rescue depicting a search and rescue situation. However, the present invention may be used in various other applications such as land based rescue missions and law enforcement applications, i.e. stolen vehicle recovery or fugitive apprehension. The beacon **120** preferably is attached to a person or object above the water surface and emits continuous RF signals **125** of a predetermined frequency. A RF signal locator **100** on vessel **10** receives the RF signal **125** and provides the user with way point readings to assist in the location of the beacon **120**.

FIG. **2** shows the face of a locator, RF signal locator **100** according to the present invention. Antennas **101***a*–**101***d* extend from the base of signal locator **100** in order to receive RF signals upon activation by the user. FIG. **3** shows a graphical interface and control buttons associated with the signal locator **100**. A power control button **106** activates the signal locator **100** for operation. Before initiating a search, the user sets the search frequency by using a channel frequency selector **104**. The receiver may be set at any desired search frequency, although a number of the search and rescue missions involve locating beacons that transmit at 121.5 MHz. During operation a user may initiate a data acquisition by using an electrical switch represented as a search trigger **102**. Although, trigger **102** is shown as a control switch button, the trigger may also be activated through the use of an actual trigger, not shown, on the underside of the signal locator **100**. Another contemplated embodiment includes the signal locator **100** without any triggering mechanism, wherein the signal locator **100** upon activation continuously measures power changes in order to determine the path loss slope. A processor, not shown, within the receiver provides distance estimations based upon the path loss slopes.

A graphical reading display (GRD) **110** provides a display of the real time data and output data processed during the search. A RF signal strength display **116***a* shows the signal strength reading numerically and graphically. A user pivots or rotates in a 360 degree direction while pointing the signal locator **100** outwardly toward different compass headings in order to initially locate the direction of the RF signal source. The RF signal strength display **116***a* displays the real time power levels, wherein the power level readings assist in determining the direction of the signal source. Above the RF signal strength **116***a*, compass **116***b* displays the direction that the signal locator **100** is pointing and changes accordingly upon movement. Below the signal strength display **116***a*, a search data display (SDD) **114** provides the user with specific data regarding the different search modes and the associated weighting of each mode.

The signal locator **100** includes three search modes: power slope calculation, triangular vectors and data mapping. Each search mode is always active and uses global positioning system (GPS) data, direction data and power level data to associate the resulting way points for each mode with an associated weight, i.e. confidence factor. The mode that is weighted the heaviest is displayed on the recommended mode way point section of the display using a standard GPS reading protocol. The SDD **114** displays the GPS reading for each search mode below the recommended mode way point and provides the weighting for each reading. The factors for processing which way point to use of the different modes are the distance traveled toward, away or perpendicular to the RF beacon signal and whether a directional antenna is being used.

Below the SDD **114**, a way point display (WPD) **112** provides the user with specific compass direction and distance information. The compass direction and distance information gives the user the estimated distance and direction of the RF signal beacon source. The distance and direction

information may change as more data is acquired and processed, and consequently more accurate readings are produced as the user approaches the RF signal source.

Referring now to FIG. **4**A, a graphical display of RF signal power v. distance is shown. Distance is measured between the RF beacon signal source and the locator, RF receiver. The graph of FIG. **4**A shows that as distance increases, the slope associated with the path loss curve decreases to substantially zero. When a larger distance separates the signal locator **100** and the RF signal source, the signal locator **100** displays a large distance number for the way point **112**. Under most circumstances the accuracy of the way point reading at longer distances is not critical. The user simply knows at longer distances, one must simply traverse a substantial distance in order to locate the beacon. As the user continues the search toward the RF signal source and obtains more data, the receiver will read a greater slope change and appropriately provide the user with a smaller and more accurate way point reading closer to the distress signal. The present invention therefore allows the user to locate the RF signal source based upon the slope characteristics of the path loss curve. Referring to FIG. **4**B, slope readings A–F along the path loss curve are depicted. As the distance decreases, the slope readings increase A–F. Accordingly, a user receiving readings at two miles or greater clearly understands to generally proceed in the appropriate direction and that the RF signal source is a large distance away from the signal locator **100**. Having a greater certainty that the RF signal source is a substantial distance from the receiver, the user may move more swiftly without fear of over shooting the RF signal source. If the user is performing a water search and rescue, then the user does not need to fear possibly running into the RF signal source or the person in distress when receiving way point readings that represent longer distances. The distance readings based on the power slope enable users to more quickly pinpoint the RF signal source and more effectively perform a search and rescue.

FIG. **5**A shows a flow chart describing the preferred method according to the present invention. A user first initiates the search mode on the signal locator **100**, step **200**. The user then OLE_LINK1 maneuvers the signal locator **100**, step **210**, in order to pick up a directional indication, step **215**. The user begins to advance in the direction as indicated, step **220** OLE_LINK1. Next, the user manually engages the search trigger **102** (FIG. **3**) to search for a way point reading, step **225**, and the locator **100** provides the way point reading, step **230**. The user continues in the direction of the way point reading, step **235**, and manually triggers a subsequent search for a more precise way point reading, step **240**. The user continues to advance in the direction of the way point/target, step **245**, and repeats subsequent searches using trigger **102** until the RF signal source is found, step **250**.

FIG. **5**B shows an alternative method according to the present invention. The user initiates a search, step **300**. The user then maneuvers the signal locator **100**, step **310**, in order to pick up a directional indication, step **320**. A processor in the signal locator automatically is preprogrammed to provide way points based on different variables such as signal strength and location. Next, the user begins to advance in the direction as indicated, step **330**, while advancing the user receives continuous way point readings where the distance component is based on path loss slope **340**. This exemplary method allows the user to continuously advance toward the way point/target, step **350**, until the target is found, step **360**. Both the methods of FIGS. **5**A and **5**B provide the user with increasingly accurate way point readings as the user progresses toward the RF signal source. Both methods use the path loss slope to quickly and efficiently located the signal source and thus substantially minimize search time.

Referring now to FIG. **6**, the direction distance finding system contained inside the receiver is shown in the block diagram. Beam directional antennas **602** are connected to a calibrated frequency modulation (FM) receiver **604** that receives the RF signal and determines the RF signal's strength. The receiver **604** filters any noise associated with the RF signal. The RF signal received from the beacon, which is a FM signal, is then sent to a signal processing unit **606**. The signal processing unit **606** also receives data from a GPS receiver **610** and a compass **612**. A battery **620**, connected to the signal processing unit, provides power to the system. The signal processing unit **606** provides real-time data to the real-time compass, GPS and signal strength displays **614** for display on a readout display **625**. The signal processing unit **606** also sends data to a data processor **608***a*, where the data processor **608***a* outputs predicted distance, direction and GPS coordinates based on the slope, triangulation or data mapping modes and the direction of the strongest signal strength where an associated weight for each mode **618** shows on the readout display **625**. The data processor **608***a* functions based upon instructions from a memory unit **608** which also stores data received from the data processor **608***a*. Based on the information received by the signal processing unit **606**, when the user activates a switch such as a trigger, the signal processing unit **606** will provide the new waypoint readings in the embodiment that includes a trigger for use by the user. Sensitivity down to 113 decibels milliamps is typical for the handheld version. By using the signal processing unit **606** and the memory **608**, the receiver can provide predicted distance readings based on relative signal strength as the user approaches the beacon.

Referring now to FIG. **7**, another exemplary application of the present invention is shown. A monopole antenna **450** installed on a vehicle **440** receives RF signals **425** emitted by a source beacon **420**. A user in the vehicle **440** initiates a search for the beacon **420** by traveling over a certain area. A signal locator display, not shown, provides information to the user regarding the reception received by the antenna **450**. FIG. **7** shows two exemplary paths that may be traversed by the vehicle **440** in order to locate the beacon **420**. Based upon the operator of the signal locator and the route available to the user, either path #**1** or path #**2** may be traversed in order to locate the beacon **420**. Regardless of the route endeavored by the user, the signal locator consistently enables the user to locate beacon **420**. Different resultant paths may be traversed due to the terrain, buildings and atmospheric conditions, all of which may affect the received signal. The signal locator obtains initial signal strength and displays a waypoint based upon subsequent strength readings of the received RF signal over a certain area. The signal locator continuously receives RF signals and generates subsequent way point readings based on the received RF signal. The subsequent way point readings guide the user to the beacon **420** and allow the user flexibility in traversing toward the beacon **420** based upon terrain and environmental conditions.

The instant invention has been shown and described herein in what is considered to be the most practical and preferred embodiment. It is recognized, however, that departures may be made therefrom within the scope of the invention and that obvious modifications will occur to a person skilled in the art.

What is claimed is:

1. A method for locating a RF signal source using a signal locator comprising:

a. initiating a search using the signal locator;

b. obtaining a direction for the RF signal source based upon RF signal readings;

c. moving a certain distance with respect to the direction of the signal and obtaining an initial waypoint reading, where the initial way point reading is based upon the rate of change of the RF signal strength as received by the signal locator;

d. continuing to traverse with respect to the initial way point reading; and

e. continuously obtaining subsequent way point readings based upon subsequent directional readings and subsequent distance readings, where the subsequent distance readings are based upon the rate of change of the RF signal strength as received by the signal locator.

2. The method for locating the source of a RF signal according to claim 1 further comprising the step of:

a. triggering each subsequent way point reading.

3. The method for locating the source of a RF signal according to claim 1 further comprising the step of:

a. selecting a terrain variable associated with the signal locator.

4. The method for locating the source of a RF signal system according to claim 3, wherein the terrain variable is selected from a range of free space to high density terrain.

5. The method of claim 1, wherein said way point reading is displayed using GPS coordinates.

6. The method of claim 1 further comprising the step of:

a. designating a RF signal frequency.

7. The method for locating the source of a RF signal according to claim 1, further including the step of providing a compass reading for direction.

8. The method for locating the source of a RF signal according to claim 1, further including the step of providing at least one search mode.

9. The method for locating the source of a RF signal according to claim 8, wherein the at least one search mode includes a power slope mode, a triangulation mode and a data mapping mode.

10. The method for locating the source of a RF signal according to claim 1, further including the step of providing a visual display for the signal locator.

11. The method for locating the source of a RF signal according to claim 10, further including the steps of:

a. incorporating a signal strength reading on the visual display;

b. displaying the initial way point reading on the visual display; and

c. displaying a recommended search mode on the visual display.

12. The method for locating the source of a RF signal according to claim 9, further including the step of providing a GPS coordinate for each search mode.

13. The method for locating the source of a RF signal according to claim 1, further including the step of designating a RF frequency of about 121.5 MHz.

14. The method for locating the source of a RF signal according to claim 1, wherein said signal locator is at least one of a handheld signal locator and a mobile signal locator.

15. A method for locating a RF signal source using a signal locator comprising:

a. initiating a search using the signal locator;

b. maneuvering the signal locator toward a plurality of compass directions in order to obtain a RF signal strength $OLE_{13}LINK2$ in the plurality of compass directions OLE _LINK2;

c. obtaining a direction for the RF signal source based upon the RF signal strength in the plurality of compass directions;

d. providing an initial compass reading toward the signal source;

e. advancing the signal locator in the direction of the initial compass reading;

f. initiating a way point reading, based on the directional readings and distance readings, where the distance readings are based upon the rate of change of the RF signal as received by the signal locator;

g. continuing to advance the signal locator;

h. initiating a subsequent way point reading, based on subsequent directional readings and subsequent distance readings, where the subsequent distance readings are based upon the rate of change of the RF signal as received by the signal locator;

i. continuing to advance the signal locator; and

j. repeating steps g–i until the RF signal source is located.

16. The method for locating the source of a RF signal according to claim 15 further comprising the step of:

a. triggering each subsequent way point reading.

17. The method for locating the source of a RF signal according to claim 15 further comprising the step of:

a. selecting a terrain variable associated with the signal locator.

18. The method for locating the source of a RF signal system according to claim 17, wherein the terrain variable is selected from a range of free space to high density terrain.

19. The method according to claim 15, wherein said way point reading is displayed using GPS coordinates.

20. The method according to claim 15, further comprising the step of:

a. designating a RF signal frequency.

21. The method for locating the source of a RF signal according to claim 15, further including the step of providing at least one search mode.

22. The method for locating the source of a RF signal according to claim 21, wherein the at least one search mode includes a power slope mode, a triangulation mode and a data mapping mode.

23. The method for locating the source of a RF signal according to claim 15, further including the step of providing a visual display for the signal locator.

24. The method for locating the source of a RF signal according to claim 23, further including the steps of:

a. incorporating a signal strength reading on the visual display;

b. displaying the initial way point reading on the visual display; and

c. displaying a recommended search mode on the visual display.

25. The method for locating the source of a RF signal according to claim 23, further including the step of providing a GPS coordinate for each search mode.

26. The method for locating the source of a RF signal according to claim 15, further including the step of designating a RF frequency of about 121.5 MHz.

27. The method for locating the source of a RF signal according to claim 15, wherein said signal locator is at least one of a handheld signal locator and a mobile signal locator.

28. A method for locating a RF signal source using a signal locator comprising:

a. initiating a search using the signal locator;

b. obtaining a signal strength level for the RF signal;

c. traversing in any direction while simultaneously obtaining data over an area;

d. traversing to a displayed waypoint, where the waypoint is based upon the obtained data; and

e. continuously obtaining data for subsequent waypoint readings by traversing toward the displayed waypoint.

29. A receiver for locating a RF signal source comprising:

a. a signal processor which processes RF signals received by the receiver;

b. a memory device;

c. software residing on said memory device, where said software includes a plurality of operating instructions;

d. an activation mechanism, where the activation mechanism initiates the receiver into a search mode; and

e. a graphical display, said the graphic display displaying way point data based on RF signals received, said way point data providing a direction of the RF signal source and a distance between the RF signal source and the receiver, said distance being based upon a path loss slope of the RF signals.

30. A system for locating a RF signal source comprising:

a. a signal locator;

b. a graphical display on said signal locator;

c. a processor within the locator, said processor receiving and measuring RF signals emitted by the RF signal source;

d. an initial way point reading displayed on said graphical display, where said initial way point display including directional and distance data associated with the RF signal source, said directional and distance data being based upon the received RF signals; and

e. continuous subsequent way point readings displayed on said graphical display, said subsequent way point readings including directional and distance data associated with the RF signal source, and said distance data being based upon a path loss slope of the received RF signals.

31. The system for locating a RF signal source according to claim 30, wherein said signal locator is at least one of a handheld locator and a mobile locator.

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